

In conclusion, the temperature at the surface of the ground has been shown to be markedly dependent upon local conditions. Many of these local conditions are under the control of man, and a better understanding of them would result in beneficial returns to the agriculturist.

### THE SUN-SPOT PERIOD AND THE TEMPERATURE AND RAINFALL OF JAMAICA.

By MAXWELL HALL, Government Meteorologist, dated December 5, 1901.

At Kingston, Jamaica, the usual meteorological instruments were read from June, 1880, to the end of 1886, at 7 a. m., 3 p. m., and 11 p. m., mean local time, and the mean of the three readings was assumed to be the mean of the twenty-four hours. From January, 1887, to March, 1899, when the weather service was closed, the instruments were read at 7 a. m. and 3 p. m. only, and no means for the twenty-four hours were taken.

From the hourly readings of a very fine barograph registering almost continuously by photography, it appears that the above assumption as to the daily averages was correct as far as barometric pressure was concerned, but from the thermograph recently kept by the United States station at Halfway Tree near Kingston, it appears that the assumption was not correct for temperature.

Careful investigation shows that the average daily temperature may be determined by the use of either one of two formulæ, which we will call A and B:

$$(A) \text{ Mean temperature of the 24 hours} = \frac{M + m}{2} - 1^{\circ}, \text{ where}$$

$M$  and  $m$  are the maximum and minimum readings, respectively;

$$(B) \text{ Mean temperature of the 24 hours} = \frac{7 \text{ a. m.} + 3 \text{ p. m.}}{2},$$

As we are unable at present to decide which is the better of the two, without hesitation we take at once—

$$\text{mean temperature of the twenty-four hours} = \frac{A + B}{2}.$$

The following table gives the means for the eighteen complete years that the service was in existence; the readings were taken by Mr. Robert Johnstone, and the errors of the instruments were checked from time to time by means of a ther-

mometer verified at Kew, England, three times during the eight years.

The thermometers were placed in a Stevenson's screen on a grass lawn about 50 feet above sea level.

#### Summary of Kingston mean temperatures for each year.

Year.	24 hours.	7 a. m.	3 p. m.	Max.	Min.	Highest.	Date.	Lowest.	Date.
1881	79.0	75.7	84.0	87.2	71.3	93.8	July 7	60.3	Jan. 13
1882	78.8	75.6	84.0	86.4	71.2	92.2	Aug. 27	61.5	Feb. 6
1883	79.0	75.6	84.1	86.8	71.5	93.3	July 28	63.6	Dec. 10
1884	78.5	75.3	83.8	86.3	70.7	92.7	Sept. 18	62.3	Feb. 7
1885	79.4	76.6	84.3	86.9	71.6	95.2	Nov. 6	58.2	Dec. 29
1886	79.5	76.6	84.5	89.0	70.9	96.4	Oct. 1	62.2	Jan. 26
1887	78.4	74.6	83.4	88.3	69.3	93.3	July 21	56.7	Dec. 4
1888	79.4	75.3	85.1	88.9	70.1	94.6	July 28	59.6	Jan. 5
1889	79.7	75.0	85.5	89.5	70.9	94.3	July 28	60.0	Mar. 2
1890	78.2	73.1	84.1	87.9	69.8	94.4	July 21	60.2	Feb. 4
1891	79.0	74.1	84.7	87.5	71.5	96.7	Aug. 20	61.5	Jan. 27
1892	78.1	73.6	83.4	86.7	70.7	94.8	July 11	63.0	Feb. 2
1893	77.9	73.3	83.2	86.5	70.6	92.9	July 4	63.8	* Mar. 17
1894	78.0	73.7	83.3	86.7	70.3	92.9	June 22†	61.2	Mar. 9
1895	78.6	73.7	84.3	87.5	71.0	94.6	Aug. 17	62.8	Dec. 21
1896	79.2	74.2	84.7	87.8	71.9	93.9	July 18	62.7	Jan. 15
1897	79.1	74.2	84.7	87.8	71.7	94.0	Aug. 9	62.0	Jan. 12
1898	78.2	73.3	83.6	86.9	70.7	93.5	Jan. 13	62.6	Nov. 12
Means	78.8	74.6	84.2	87.5	70.8	94.1	.....	61.3	.....

\* And December 7. † And July 17 and September 21.

The first thing to be noticed is the break in the 7 a. m. readings. From 1881 to 1889 the mean is 75.5°; from 1890 to 1898 the mean is 73.7°. During the first nine years the screen was as well exposed as possible; during the last nine years it was exposed on the Parade Gardens, which had been recently planted with ornamental shrubs of all kinds. Of late years these shrubs have grown to be trees, and have caused anxiety as to the exposure of the screen, but it appears that the exposure was bad at first, and has not become worse with the growth of the trees. It is to be noticed, however, that the daily maximum temperatures, which occur shortly after noon, are in no way affected by the ornamental shrubs or trees. The sun is then vertical, or nearly so, and of course the screen is exposed to its full blaze. This also applies to the 3 p. m. readings. Again, the minimum readings have not been affected. It is therefore to be hoped that the mean temperatures, as computed by the formula  $\frac{A + B}{2}$ , are not greatly

in error. But when we look down the maximum column we are surprised to find that the two lowest results occur in 1884

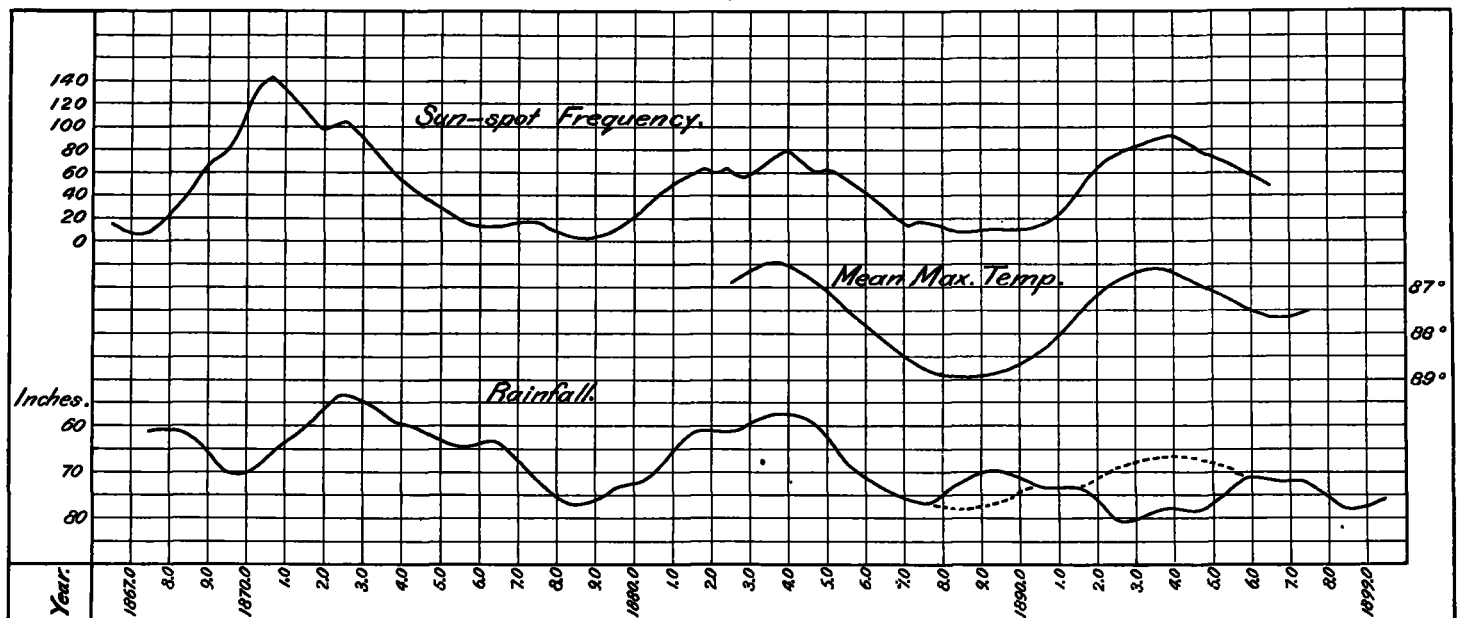


FIG. 1.—Sun spots, temperature, and rainfall for Jamaica.

and 1893 near the times of the sun-spot maxima, and that the highest result occurs in 1889 at the time of the sun-spot minimum.

These effects are reproduced in the twenty-four hour mean temperature column, but without doubt we ought to look to the mean of the daily maxima throughout the year to show any variation in the intensity of solar radiation. This may be done in the same manner that the connection between the sun-spot period and the rainfall in Jamaica<sup>1</sup> was shown, by taking the mean of any three years as the mean of the middle year, and thus reducing the irregularities. Applying this process to the mean maximum temperature we get the following table:

Mean maximum temperatures (smoothed).

1882	86.8
1883	86.5
1884	86.7
1885	87.4
1886	88.1
1887	88.7
1888	88.9
1889	88.8
1890	88.3
1891	87.4
1892	86.9
1893	86.6
1894	86.9
1895	87.3
1896	87.7
1897	87.5

It seems advisable to give in fig. 1 the three curves for sun-spot frequency and mean maximum temperature and rainfall in Jamaica, the two latter curves being smoothed by taking the mean of the results for any three years as the mean result for the middle year.

In the rainfall curve irregularities will be noticed, as shown by the dotted curves. From the middle of 1887 to the middle of 1890 the rainfall was less than it should have been. From the middle of 1891 to the end of 1895 it was greater than it should have been.

Attention is strongly called to these irregularities, because in 1892 it was assumed that the curve would recover its position, and in consequence a smaller rainfall for the next few years was predicted; but 1893 proved unusually wet, producing the smoothed maximum for the middle of 1892.

The following table gives the rainfall in Jamaica as deduced from about ninety stations:<sup>2</sup>

Annual rainfall for Jamaica.

Year.	Rainfall.	Average for 3 years.	Year.	Rainfall.	Average for 3 years.
	Inches.	Inches.		Inches.	Inches.
1886	53.55	61.95	1884	56.80	58.07
1887	64.47	61.95	1885	59.86	69.12
1888	67.74	62.53	1886	60.61	73.71
1889	55.87	70.85	1887	70.66	77.79
1890	59.43	64.96	1888	72.11	72.81
1891	50.09	61.57	1889	74.15	70.23
1892	45.18	52.78	1890	64.43	74.42
1893	63.06	59.06	1891	84.70	74.03
1894	68.94	61.47	1892	72.93	81.39
1895	52.42	64.24	1893	66.49	78.29
1896	71.35	64.06	1894	75.39	77.83
1897	68.40	72.06	1895	71.62	71.87
1898	76.42	77.89	1896	68.61	72.61
1899	58.94	73.57	1897	77.59	73.35
1900	55.44	70.96	1898	73.84	79.08
1881	68.60	60.64	1899	85.82	76.44
1882	57.57	61.91	1900	69.65	.....
1883	59.26	58.01			

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W. F. R. PHILLIPS, in charge of Library, etc.

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- Pearson's Magazine*. London. Vol. 12.  
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<sup>1</sup> Nature. Vol. 49. P. 399.

<sup>2</sup> The tabular sun-spot numbers are given on page 506 of the current REVIEW.